

THE NATURE AND ORIGIN OF THE FISHES OF THE
PACIFIC SLOPE OF ECUADOR, PERU AND CHILI.¹

(PLATES VIII-X)

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There are three distinct faunas on the Pacific slope of South America and west of the Cordillera of Bogota.

One of these, the richest, occurs in Panama, southeast of the Canal Zone, and in Colombia, west of the Cordillera of Bogota.

The second of these faunas occurs in the Guayas basin of Ecuador, and trails southward at least to the Rio Rimac at Lima.

The third occupies the Pacific slope of Chili trailing northward to the Rio Rimac or possibly the Rio Santa.

The first two are part of the tropical American fauna. The third belongs to the south temperate fauna.

In a series of articles I have dealt with the nature and origin of the freshwater fishes of Panama,² of the Pacific slope of the Cordillera Occidental of Colombia,³ of the Magdalena river basin,⁴ of the Cordillera of Bogota,⁵ and of the general horizontal distribution of all of the fishes west of the basins of Lake Maracaibo and Titicaca, and west of the Orinoco and Amazon river basins.⁶

¹ Contribution from the Zoölogical Laboratory of Indiana University, No. 181.

² "The Freshwater Fishes of Panama East of 80° West," *Indiana University Studies*, No. 47, pp. 3-19, 1921.

³ "The Fishes of the Rivers Draining the Western Slope of the Cordillera Occidental of Colombia," I. c., No. 46, pp. 1-20, 1921.

⁴ "The Magdalena Basin and the Horizontal and Vertical Distribution of its Fishes," I. c., No. 47, pp. 21-34, 1921.

⁵ "The Fish Fauna of the Cordillera of Bogota," *Journ. Wash. Acad. Sci.*, X., pp. 460-468, 1920.

⁶ "South America West of the Maracaibo, Orinoco, Amazon, and Titicaca Basins, and the Horizontal Distribution of its Freshwater Fishes." *Indiana University Studies*, No. 45, pp. 1-24, 1920.

These articles deal with the first of the faunas mentioned above. I propose in the present paper to deal with the nature and origin of the freshwater fishes of the Guayaquil basin of Ecuador, of the rivers and lakes of Chili north of Puerto Montt and of the rivers between these areas, *i.e.*, of all the Pacific slope rivers between northern Ecuador, near the equator, and Puerto Montt, $41^{\circ} 28' S$. The material for this study was collected by Mr. Arthur Henn of the Landon Ecuadorian Expedition of Indiana University in 1913, and by Dr. William Ray Allen, Dr. Adele Eigenmann and myself of the Irwin Expedition of Indiana University and the University of Illinois between June, 1918, and June, 1919.⁷

THE GUAYAS BASIN AND ITS FISHES (PLATE VIII.).

North of the desert of Tumbes the coast range of Ecuador consists of cretaceous formations trending from Guayaquil north-westward and reaching a height of 2,300 feet. North of about $1^{\circ} 50'$ south latitude the cretaceous joins tertiary hills reaching a height of from 600 to 1,000 feet and extending north to the Rio Santiago. North of the Rio Chone the hills approach the coast and are relatively younger (late tertiary and quaternary). South of the Rio Chone a wider or narrower quaternary territory extends

⁷ Several additional rivers should receive consideration at the earliest moment, the Esmeraldas in Ecuador; the Santa, the largest river of Peru; the lower Loa, an isolated river in northern Chili; and the Bio Bio, the largest river in Chili. Between Puerto Montt and Cape Horn there is a series of large rivers and lakes concerning which we know nothing. It has been suggested that they be searched for *Cerotodus*.

The Esmeraldas drains the area immediately north of the Guayas basin. Very little is known of its fauna. The Santa is the largest river of the Pacific slope of Peru and may be expected to contain a more complete complement of the ancient fauna of the Pacific slope of Peru than any of the rivers examined. The Loa in northern Chili is widely separated by deserts both from the nearest rivers to the north and the nearest rivers to the south. Its fishes, if there are any, should determine whether this portion of Chili belonged in the past to the tropical American faunal area or to the Patagonian.

The Rio Bio Bio, the largest basin in Chili, contains all of the fishes found in the rivers of Chili north of it and is "farthest north" of the peculiar fauna with Australian affinities which finds its culmination in the south of Chili.

along the coast to the Gulf of Guayaquil. East of the coast range, between the Guayas and the Esmeraldas rivers, lies a quaternary plain 60 to 250 feet high and 30 to 50 miles wide. East of this rises the Cordillera Occidental. About Guayaquil and along the coast to the Rio Tumbez there are recent alluvial flat lands. The coastal quaternary lands are drained by the Rios Chone and Portoviejo, two short rivers emptying into the Pacific between 30' and 40' south.⁸ The interior quaternary lowlands are drained in the north by the Quininde and Toachi which empty into the Esmeraldas. The greater, southern part is drained by the affluents of the Rio Guayas, the Chan Chan, Chimbo, Caracoles, Vinces and Daule, with their tributaries. I have elsewhere compiled an account of the Pacific slope of Ecuador and need repeat only that the height of land between the Rio Esmeraldas and some of the head-waters of the Guayas is negligible as a barrier to fresh-water fish migration. The usual ability to drag a boat from one system to the other is reported. (Sievers, "Süd und Mittelamerika," p. 459.) The fishes should, therefore, be the same in the two streams.

The Guayas basin differs from all others south of the Rio San Juan of Colombia. The Guayas and the Vinces have a course parallel with the general trend of the Andes and for many miles flow through lowland. Farther north the Dagua and the Patia, and

⁸ Mr. Arthur Henn, who visited this region, reports:

"As I recall the rivers at Chone and Portoviejo, they are approximately of the same size. These rivers arise in seasonally humid hills of about 1,200 feet in height. The coastal area is quite arid. At Bahia when I was there they were bringing in drinking water by tank car on the railroad from the interior, and Manta on the coast west of Porto viejo is almost an absolute desert. Water for cooking and washing was secured by means of wells sunk in the sand. Water filtered in from the sea and was slightly saline. Drinking water was brought in by donkey from the interior. South of Manta, near Santa Elena, the same desert continues with vast arid dunes. At Chone and Porto viejo which are more in the interior, the people can always secure water from pools in the river. During the rainy months these rivers are wide, deep, muddy streams and I believe it is possible to get up in a small launch from Bahia to Chone. When I was there, however, the rivers were small creeks with fords at numerous intervals, and numerous bamboo bridges which would be washed out in time of flood. The only water over waist-deep was the occasional deep pool. I understand from the people that in times of severe drought the river disappears entirely except for these occasional pools."

farther south the Jequetepeque, Rimac, etc., flow from the Cordilleras directly to the sea. The Guayas basin lies between the great coastal desert of Peru and the extremely wet region of southern Colombia. It is the largest river basin of the Pacific slope north of Chili.

The fish-fauna of the Guayas basin is old and highly specialized. It gradually tapers off southward as one and another genus and species have been excluded or exterminated by the elevation of the Andes, resulting in torrential courses, high seasonal variation in the amount of water and great fluctuations in the amount of silt carried, all conditions unfavorable to fishes.

The fishes on the Pacific slope of Colombia are quite distinct from those of Ecuador and Peru.

The fishes of the Patia, in southern Colombia, are essentially like those of the San Juan, in central Colombia. On the other hand, the fishes of the Guayas and the San Juan basins, the former in the wet zone, the latter in the dry zone, are essentially different. The line separating the two faunas lies somewhere near the Mira and Esmeraldas basins.

Little is known of the fishes of the Esmeraldas. Several notable contributions to the fauna of the Guayas have been published. One of these is Kner and Steindachner's "Neue Gattungen und Arten von Fischen aus Central-America gesammelt von Prof. Moritz Wagner" (*Abhandl. k. bayer. Akad. Wiss.*, München, X., 1864). The general bearing of the facts was discussed by Wagner, in the same volume, pp. 93-109. Another is Steindachner's "Zur Fisch-Fauna des Cauca und der Flüsse bei Guayaquil" (*Denksch. K. Akad. Wiss.*, Wien, XLII., 1880, pp. 55-104, 9 plates).

A third contribution of note to this region is: Boulenger's *Poissons de l'Equateur*.⁹

In this paper Boulenger describes or lists the specimens collected by Festa in a trip across southern Ecuador from Santa Elena through the Guayas basin to the Rios Zamora, Santiago and Bamboiza rivers. The last three are parts of one system tributary to the

⁹ "Viaggio del Dr. Enrico Festa nell'Ecuador e regione vicine," *Bolletino, Musei Zool. Anat. comp. della Univ. di Torino* (Première Partie), XIII., No. 329, Dec. 2, 1898; (Deuxième Partie), XIV., No. 335, Feb. 15, 1899.

Marañon, in eastern Ecuador. He refers in the same paper to *Brycon atricaudatus* collected by Rosenberg at Paramba in the Mira basin, and describes as new *Tetragonopterus simus* from the Chota valley in northern Ecuador (Mira basin).

The localities given for a number of species make it doubtful whether the identification is correct or whether the locality label with the specimen has not been misplaced. It is questionable, for instance, whether *Astyanax fasciatus* was taken in the Peripa, whether *Brycon atricaudatus* came from east of the Andes, whether the specimens identified as *Salminus affinis* from east of the Andes are the same as the *Salminus affinis* from the Cauca River; whether the *Leporinus* from the Vinces is the *frederici* of the eastern rivers, whether the specimens listed under *Brycon striatulus* from the Rio Santiago actually belong to that west coast species; whether the *Pygidium tænium* is the same as the *tænium* from the elevated portions of the western slope of the Andes; whether, finally, *Chætostomus dermorhynchus* is actually present both on the Atlantic and the Pacific sides of the Andes of Ecuador.

Sixty-odd species of fresh-water fishes have been taken in the Guayas basin. Of these the species of *Astroblepus* and *Pygidium* belong to the highest altitudes and follow their own laws of dispersal. Twenty belong to families and genera that are found only in the lowland, some of them indifferently in salt or fresh water (*Hexanemichthys*, *Stolephoridae*, *Hæmulidae*, *Tylosurus*, *Centroponidae* and *Gobiidae*).¹⁰ This leaves of strictly fresh-water species only forty. Of the forty only *Sternopygus macrurus* is certainly found east of the Andes.¹¹ Only four of the species extend north of the Rio Esmeraldas.¹² These are *Chætostomus fischeri* north to the Chagres; *Chætostomus marginatus* north to the San Juan;

¹⁰ They are marked with * in the table.

¹¹ *Hemibrycon polyodon* is recorded from the basin of the Santiago east of the Andes. It is quite within possibilities that the specimens recorded from Guayaquil also came from the east. Pellegrin has recorded *Ancistrus bufonius* from the Rio Pove at Santo Domingo de los Colorados, 560 m. I am not sure whether the Pove drains into the Esmeraldas or the Guayas, but the identification may be doubted for the present.

¹² *Brycon atricaudatus* has been recorded from the R. Mira just north of the Esmeraldas.

Sternopygus macrurus found to the Atrato and Magdalena; and *Hoplias microlepis* which, aside from the Guayas basin, is found also in the Chagres.

Of these four *Sternopygus macrurus* attains a much larger size in the Guayas than elsewhere and may represent a variety distinct from the northern and eastern specimens. It is the only species of the Guayas also found in the Magdalena and east of the Andes.

Hoplias microlepis disappears north of the Esmeraldas to reappear again in the Chagres. The entire region between is occupied by *Hoplias malabaricus*.

Only four species extend south into Peru: *Lebiasina bimaculata* and *Bryconamericus peruanus* to the Rio Rimac, *Æquidens rivulatus* and *Brycon atricaudatus* to Pacasmayo.

The remaining species are confined to the Guayas and the immediate neighborhood.

The 34 strictly fresh-water fishes belong to 28 genera (not counting *Gambusia* and *Ancistrus*, which are in doubt) of which seven (25 per cent.) are peculiar, *Paracetopsis*, *Saccodon*, *Pseudochalceus*, *Phenacobrycon*, *Landonia*, *Rhoadsia*, *Pseudopacilia*. All but one of the rest of the genera, *Microglanis*, are also found in the north and all but one, *Lebiasina*, east of the Andes.

The Guayas fauna is as distinct from that of the Magdalena as from that of the Amazon. *It differs more from the fauna of the Patia, emptying into the Pacific only a hundred miles north of the Esmeraldas, than the Magdalena fauna differs from that east of the Andes.*

Whence came the ancestors of the Guayas fishes?

Pseudopacilia, one of its peculiar genera, is of undoubted northern derivation. *Hoplias microlepis*, found elsewhere only in the Chagres, and possibly *Rhoadsia*, scarcely distinct from *Parastremma* which extends to Costa Rica, may also indicate that the ancestors of these present genera came from the north. The probability seems, however, equally great that they arose in the Guayas and moved north or that the species both north and south are independent developments from the fauna originally segregated from the east. Pellegrin records a *Pacilia*¹³ from the Rio Pove. Whatever the

¹³ The name *Pacilia pellegrini* may be applied to this species.

species may be it is certainly of northern origin. Regan identifies some specimens from Ecuador as *Bryconamericus scleroparius*, a Costa Rican species.

Microglanis, *Paracctopsis*, *Leporinus*, *Prochilodus*, and possibly *Curimatus*, indicate that the ancestors of the Guayas fishes came from the east. *Microglanis* is found east of the Andes but not in Colombia. *Paracctopsis* has its nearest relative in the Amazon, not in the north. *Plecostomus*, *Ancistrus?*, *Apareiodon?*, *Leporinus* and *Prochilodus* are found both in the Amazon and in Colombia but there is a hiatus in their distribution reaching from the San Juan to the Esmeraldas. They probably came independently into the Magdalena and into the Guayas. While *Curimatus* ranges everywhere in Colombia, the Ecuadorian species are very distinct from *Curimatus lineapunctatus* and its variety *patia*, the only ones in the region between the Atrato and the Esmeraldas. *Curimatus* came independently into the Magdalena and into the Guayas. The same may be true of *Sternopygus macrurus*.

It is seen above that the ancestors of one of the genera peculiar to the Guayas, *Pseudopacilia*, came from the north, those of another, *Paracctopsis*, from the east. The other five do not give very clear evidence in favor of the eastern or northern origin of the Guayas fauna.

Saccodon is related to *Parodon* found both in Colombia and east of the Andes. Its ancestors may have come from either place.

Phenacobrycon is a derivative of *Bryconamericus*, an artificial conglomeration of fishes, allied to *Astyanax*, abundant both east of the Andes and in Colombia.

The nearest relative of *Pseudochalceus* is *Hollandichthys* of southeastern Brazil. Are they of independent origin from *Astyanax*? Does the territory between them contain related forms?

Landonia is a minute derivative of *Astyanax*, a genus which is found everywhere. I do not see that it gives any evidence on the origin of the ancestors of the Guayas fishes.

Rhoadsia was mentioned above. It belongs to a subfamily peculiar to the Pacific slope of Ecuador and Colombia which also extends to Costa Rica. The young show all the characters of the Cheiro-

dontinae found both in Colombia and east of the Andes. It does not help us to solve the question of the origin of the Guayas fauna.

Another genus of importance is *Lebiasina*, a recent derivative of *Piabucina*, into which it still merges. *Piabucina* is found both in Colombia, Venezuela, and in eastern Ecuador. The ancestors of some of the species of *Piabucina* in Colombia may have come from Venezuela and those of Ecuador may have come independently from the Amazon.

The fauna of the Guayas is certainly quite distinct from that of western Colombia.

South of the Guayas basin the question has simply been which of the Guayas species originally segregated have been able to live or survive in the unfavorable conditions offered by the desert slopes of Peru.¹⁴

The fauna of Peru is a fauna of relicts. Of the nine species in the Jequetepeque, four are found in the Guayas. Of the five species of the Rimac, two are found in the Guayas, one is Chilean, one belongs to the high Andes, and one is a local form of a genus found in the Guayas.

LIST OF THE GUAYAS GENERA AND THEIR PROBABLE DERIVATION OR
THE PROBABLE DERIVATION OF THEIR ANCESTORS.

<i>Paracetopsis</i>	.... from the east.	
<i>Microglanis</i>	.... from the east.	
<i>Rhamdia</i>	..... from the north or east.	Originally from the east.
<i>Pimelodella</i>	..... from the north or east.	Originally from the east.
<i>Plecostomus</i>	.... from the east.	
<i>Hemiancistrus</i>	.. from the north or east.	
<i>Ancistrus</i> ¹⁵	..... from the east.	
<i>Chatostomus</i>	... from the north or east.	
<i>Curimatus</i>	..... from the east.	
<i>Apareiodon</i>	.... from the east.	
<i>Saccodon</i>	..... from the east.	
<i>Prochilodus</i>	..... from the east.	

¹⁴ I have elsewhere described how at Piura the water in the Rio Piura during the dry season was restricted to a few pools around the pier of the bridge, around some rocks, etc., and how the fauna was concentrated in these pools where the individuals were starved to the point of death.

¹⁵ In the Esmeraldas or Guayas?

- Leporinus* from the east.
Piabucina from the north?
Hyphessobrycon from the east.
Astyanax from the east.
Phenacobrycon . from the north or east.
Bryconamericus . from the north or east.
Pseudochalceus . from the east.
Landonia from the east.
Brycon from the north or east.
Hemibrycon from the east.
Rhoadsia from the east.
Hoplias from the north or east.
Sternopygus from the (north or?) east.
Pseudopæcilia . . . from the north.
*Gambusia*¹⁶ from the north.
Æquidens from the north or east.
Cichlasoma from the north or east.

I have formerly expressed the opinion that the Guayas fauna probably came from the Amazon basin east of it.¹⁷ This explanation has been greatly strengthened for part of the fauna by the present study. This part may have been segregated from the Amazon fauna as the Magdalena fauna was later segregated from the fauna of the present Orinoco basin. The present study also furnishes some evidence that in times more remote than the origin of the present San Juan fauna part of the Guayas fauna (*Hoplias microlepis* may have been derived from the north. If so, the fauna between the Patia and the Canal Zone was subsequently obliterated and the area between Panama and the Patia became repopulated later by way of the Atrato and San Juan, the Guayas fauna remaining intact all the while and containing *Hoplias microlepis*, *Leporinus*, and *Prochilodus*, which have not been able to enter the territory between the Atrato and the Mira.

At present the Guayas fauna is more different from that of the Magdalena on the same side of the Andes than that of the Magdalena is from that of the Orinoco basin across the high Andes of Bogota.

When and where the derivatives from the Amazon came across

¹⁶ In the Esmeraldas or Guayas? It was recorded from the Rio Pove.

¹⁷ A reservation must be made for *Basilichthys* which is a Chilean genus ranging north at least to the Rimac.

the Andes are difficult questions, especially in view of the fact that the principal territory at present occupied by the Esmeraldas-Guayas systems is quaternary and the Andes are, in part at least, tertiary, and are everywhere, east of the Guayas, far above the habitat of the genera whose origin is sought. Evidently the Guayas is simply the present gathering place of the Pacific slope fauna of Ecuador, not necessarily the original western habitat of these fishes.

In this connection the discovery of Berry is of interest (*Proc. U. S. Nat. Mus.*, LIV., p. 114)

“that the fossil flora found in the tuffs at Potosi is very similar to existing assemblages found in eastern Bolivia or at various other places in the Amazon basin,”

and that

“From a consideration of all the evidence available it is concluded that the flora is Pliocene in age and that the major elevation of the eastern Andes of Bolivia and the high plateau took place in the late Pliocene and throughout the Pleistocene.”

Of even greater interest is Berry's discovery (*Proc. U. S. Nat. Mus.*, LV.) that the fossil plants taken, p. 279,

“from a clay lens overlying a bed of lignite in the petroleum-bearing sands about 20 miles south of the town and river of Tumbez and 200 or 300 feet inland from the shore of the Pacific,” p. 283, “furnish convincing evidence that the coastal region of Peru during the early Miocene was a region covered with a dense tropical forest, including a variety of broad-leaved mesophytic hardwoods mixed with lianas and large feather palms, and that the climate and rainfall were in striking contrast with what they are at the present time in this region. This would seem to indicate that in the early Miocene the Ecuadorian and Peruvian Andes had not yet interposed their height in the path of the easterly moisture-bearing trade winds and that the present coastal desert was not in existence.”

This discovery shows that what is now the Pacific slope was habitable for fresh-water fishes in comparatively early time, before the Andes were the formidable barrier they now present. It is quite within reason, therefore, that the present fish-fauna of the Guayas did not come from the east across a barrier but that at a time preceding the origin of the present species a section of a continuous fauna was segregated from the rest by the formation of the mountainous screen between them.

A possible route for the intermigration of genera from the Atlantic to the Pacific side across the incipient Cordilleras may have been provided in northern Peru long after the beginning of the uplift. East of the Piura River there is a saddle in the Andes with a height of but 6,700 feet. At three thousand feet in the Magdalena basin conditions are still possible for the principal genera inhabiting the lowlands of the Guayas so that a lowering of the Andes of 4,000 to 6,000 feet would enable fishes to get across, if the conditions were otherwise favorable for the transmigration.¹⁸

The time when the segregation or translation took place can only be given in terms of the lives of species. It happened before the present species were differentiated, long enough ago to permit many genera to develop on the Pacific slope but after the general features of the tropical American fresh-water fish-fauna had appeared.

SUMMARY.

The fish-fauna of western Ecuador and western Peru has less affinity for that of the Magdalena to the northeast of it than for that of the Amazon with which it shows close relationship. Only four of its species extend as far north as the Patia.

The ancestors of but 2 of its genera certainly came from the north (Panama), the ancestors of 14 of its genera certainly came from the east, while the ancestors of the others may have come from the north or east, probably from the east. The fauna can most easily be explained on the assumption that it was segregated from a fauna continuous from the Pacific to the Atlantic by the elevation of the Andes into an insuperable barrier. The segregation happened before the evolution of the present species and before the evolution of many of the present genera. The segregated fishes

¹⁸ Prof. E. W. Berry expressed the opinion to the writer that the first uplift in the region of the Andes was eroded to mature topography, the present great height of the Andes is the result of a later uplift. The region about Junin and to a less extent about Lake Titicaca shows the ancient mature topography lifted to a height of 12,000 feet and more. Toward this highlands the streams from the east and west have cut deep gorges. Bowman according to Berry (l. c. LIV, 112) regards "the Andes as having undergone progressive elevation throughout the Tertiary and he concludes that there has been a change of elevation in the late Tertiary amounting to about 5,000 feet.

TABLE SHOWING THE RELATION OF THE GUAYAS FAUNA TO THAT OF THE RIVERS NORTH AND SOUTH OF IT.

The letters *S* and *N* indicate "farthest North," or "farthest South," for the respective species. Only those species of the San Juan to the Patia are given that are also found in Ecuador.

	San Juan to Patia.	Mira and Santiago.	Esmeraldas.	Chone.	Portoviejo.	Guayas.	Patia.	Rio Jequetepeque.	Rio Rimac.
In the following list those species which enter the ocean and may readily migrate from stream to stream by way of the ocean are marked by *.									
Cetopsidæ:									
1. <i>Cetopsogiton occidentalis</i>						—			
Siluridæ:									
2. <i>Hexanematichthys henni</i> *						—			
3. <i>H. labiatus</i> *						—			
4. <i>Pseudopimelodus transmontanus</i>	—	—S							
5. <i>Microglanis variegatus</i>						—			
6. <i>Rhamdia cinerascens</i>			N—			—			
7. <i>Pimelodella grisea</i>	—	—S							
8. <i>P. modesta</i>	—		—	—	—S				
9. <i>P. yuncencis</i>							—	—	
10. <i>P. elongata</i>			N—	—	—				
Pygiidæ:									
11. <i>Pygidium laticeps</i>		—	—						
12. <i>P. lænium</i>	—		?			?			
13. <i>P. punctatum</i>									—
14. <i>P. piura</i>							—	—	
Loricariidæ:									
15. <i>Plecostomus spinosissimus</i>						—			
16. <i>Hemiancistrus landoni</i>						—			
17. <i>H. annectens</i>	—	—S				—			
18. <i>Ancistrus bufonius</i> ¹⁹			?			—?			
19. <i>Chaetostomus fischeri</i>	—					—			
20. <i>C. marginatus</i>	—	—				—			
21. <i>C. æquinotialis</i> ¹⁹	—		?			—?			
22. <i>Loricaria jubata</i>	—	—S				—			
Astroblepidæ:									
23. <i>Astroblepus cyclopus</i>		—	—			—			
24. <i>A. grivalvii</i>	—	—	—			—			
25. <i>A. fissidens</i>	—		?			?			
26. <i>A. choia</i>	—	—	—			—			
27. <i>A. longifilis</i>	—		?			?			
Characidæ:									
28. <i>Curimatus boulengeri</i>						—			
29. <i>C. troscheli</i>						—			
30. <i>C. peruanus</i>						—			
31. <i>Apareiodon ecuadoriensis</i>						—			
32. <i>A. terminalis</i>						—			
33. <i>Saccodon wagneri</i>						—			
34. <i>S. craniocephalum</i>						—			
35. <i>Prochilodus humeralis</i>						—			
36. <i>P. stigmaturus</i>						—			
37. <i>Leporinus ecuadoriensis</i>						—			
38. <i>Lebiasina bimaculata</i>			N—	—	—	—	—	—	—
39. <i>Piabucina aureoguttatus</i>						—			
40. <i>P. astrigata</i>	—	—S				—			
41. <i>Hyphessobrycon ecuadoriensis</i>						—			
42. <i>Astyanax festa</i>				N—	—	—			
43. <i>Phenacobrycon henni</i>				N—	—	—			

¹⁹ These species are recorded from the Rio Pove, Santo Domingo de los Colorados 560 m. I am not sure whether the Pove drains into the Esmeraldas or into the Guayas.

In the following list those species which enter the ocean and may readily migrate from stream to stream by way of the ocean are marked by*.

	San Juan to Patia.	Mira and Santiago.	Esméraldas.	Chone.	Portoviejo.	Guayas.	Paíta.	Río Jequetepeque.	Río Rimac.
Characidae:									
44. <i>Bryconamericus simus</i>		—							
45. <i>Bryconamericus peruanus</i>				N—	—	—	—	—	—
46. <i>B. brevirostris</i>						—	—	—	
47. <i>B. scleroparius</i>	?	?	?						
48. <i>Pseudochalceus lineatus</i>						—			
49. <i>Landonia latidens</i>						—			
50. <i>Brycon alburnus</i>						—			
51. <i>B. atricaudatus</i>		N—				—		—	
52. <i>B. dentex</i>			N—			—			
53. <i>B. oligolepis</i>	—	—S				—			
54. <i>B. ecuadoriensis</i>						—			
55. <i>Hemibrycon polyodon</i> ²⁰						—			
56. <i>Rhoadsia altipinna</i>				—		—			
57. <i>R. minor</i>			—			—			
58. <i>Hoplias microlepis</i>				—		—			
Gymnotidae:									
59. <i>Sternopygus macrurus</i>	—					—			
Stolephoridae:									
60. <i>Sardinella stolifera</i> *	—					—			
61. <i>Stolephorus lucidus</i> *				—		—			
Pæciliidae:									
62. <i>Pseudopæcilia festæ</i>					?				
63. <i>Ps. fria</i>						—			
64. <i>Gambusia pellegrini</i>					?	—?			
65. <i>Orestias elegans</i>									—
Esocidae:									
66. <i>Tylosurus fluviatilis</i> *	—	—				—			
Mugilidae:									
67. <i>Mugil</i> ²¹ <i>curema</i> *		?	?	—	?	—			
68. <i>M. charlotta</i> *						—			
Centropomidae:									
69. <i>Centropomus unionensis</i> *						—			
70. <i>C. undecimalis</i> *	?	?	?	?	?	—			
Hæmulidae:									
71. <i>Pomadasys andrei</i> *						—			
72. <i>P. schyri</i> *						—			
73. <i>P. bayanus</i> *		?	?			—			
74. <i>P. macracanthus</i> *	—	?	?	?	?	—			
Cichlidae:									
75. <i>Æquidens cæruleopunctatus</i>		—S							
76. <i>A. sapayensis</i>	—	—S							
77. <i>A. rivulatus</i>				N—	—	—	—	—	
78. <i>Cichlasoma ornatum</i>	—	—S							
79. <i>C. festæ</i>						—			
Gobiidae:									
80. <i>Dormitor latifrons</i> *	—	?	?	—	?	—	?	—	
81. <i>Eleotris picta</i> *	—	?	?	—	?	—	?	—	
82. <i>Philypnus maculatus</i> *	—	?	?	?	?	—	—	—	
83. <i>Sicydium salvini</i>	—	—							

²⁰ This species may be extralimital, having been merely shipped from Guayaquil but collected elsewhere.

²¹ Other species and other localities of the marine *Mugil*, *Centropomus*, *Pomadasys*, etc., will probably be found in this area.

	San Juan to Patia.	Mira and Santiago.	Esmeraldas.	Chone.	Portoviejo.	Guayas.	Paita.	Rio Jequetepeque.	Rio Rimac.
In the following list those species which enter the ocean and may readily migrate from stream to stream by way of the ocean are marked by *.									
Cobiidæ:									
84. <i>Awaous transandeanus</i> *.....	—	—	?	?	?	—	?		
85. <i>Gobioides peruanus</i> *.....						—			
Batrachoididæ:									
86. <i>Batrachoides pacifici</i> *.....						—			
Soleidæ:									
87. <i>Citharichthys gilberti</i> *.....				—	?	—	—		
88. <i>Achirus klunzingeri</i> *.....				—	?	—			

later underwent an independent evolution. South of the Guayas the genera of the Guayas disappear one after another. The Peruvian rivers draining into the Pacific have lost all but that portion of the original fauna which can withstand their present torrential course and the great seasonal fluctuation of their waters.

In central Peru, the Guayas fauna and the Chilean fauna touch. In the Rio Rimac at Lima, *Bryconamericus peruanus* and *Lebiasina bimaculata* are remnants of the ancient fauna, while *Basilichthys semotilus* is the beginning of the Chilean fauna.

The reputed resemblance of the Guayas fauna to that of Central America has been based on mistaken identifications. Only *Hoplias microlepis* points to any resemblance not bridged in the distribution.

Several of the prominent genera of the Guayas are also found in the Atrato-Magdalena, but not in the region between them. They have been independently acquired by the Magdalena and by the Guayas.

THE FRESH-WATER FISHES OF CHILI.

The fishes of Chili and east of the Andes, south of a line extending from Buenos Aires to Mendoza, differ from those of tropical America to the north of this line. The fishes of this, the Patagonian Region, were described in "The Fresh-water Fishes of Patagonia and an Examination of the Archiplata-Archhelenis Theory" (*Reports Princeton University Expedition to Patagonia*, III.,

especially pages 227 to 292, plates XXX.-XXXVII.). Very few specimens were available for study during the preparation of that volume.

During the Irwin Expedition of Indiana University, Dr. William Ray Allen collected at Ascotan and at Calama, both in the Loa River of northern Chili, and I collected along the railway between Copiapo $27^{\circ} 21'$ south and Puerto Montt $41^{\circ} 28'$ south. For the most part the rivers were crossed some miles from the coast but at La Serena, Concepcion, Valdivia and Puerto Montt the streams were examined near the coast. I also collected in the Rio Blanco, of the Aconcagua basin, a tributary of the Rio Aconcagua. A series of collections was made in Valdivia and Lake Rinihue of the Calle Calle basin, and between Puerto Varas on Lake Llanquihue and Nahuel Huapi in the Argentine. The fact that the same species were observed over and over again in different localities indicates that the main features of the fauna have become known.

While the very large series of specimens collected give us more precise knowledge of the characters of the species and of the details of their distribution it is a satisfaction that the general conclusions reached in the volume mentioned above need very little modification as the result of the new study.

Physical Features.—Chili is a narrow strip of Pacific slope extending from the Rio Sama at its northern border, which empties into the Pacific at 18° south, to Punta Arenas at $53^{\circ} 10'$ south. It is 270 miles at its widest (on the Tropic of Capricorn) and 50 miles at its narrowest (between La Serena and Valparaiso). Between the Sama and Puerto Montt, Chili is crossed by innumerable valleys extending from the crest of the Andes to the Pacific. In the extreme north in Tacna, the valleys contain little or no water. North of Antofagasta there is a considerable stream, the Loa. South of the Loa for about 300 miles extends the Desert of Atacama. Between Copiapo and Valparaiso there are great valleys with a disproportionately small amount of water (Plate IX.).

A small stream passes Copiapo on its way to the ocean. South of Copiapo to Vallenar the country is arid. At Vallenar there is another stream similar to that of Copiapo and then again arid land with an occasional rain in years. A few small pools of water were

noticed in a creek bottom along the railroad toward La Serena. At La Serena a considerable stream empties into the ocean. But one native species of fish was found north of La Serena. *Cheirodon pisciculus*, a small fish, was taken at Vallenar. Copiapo contained only introduced gold fish. I was told peje rey occur near the mouth of the Rio Copiapo. This is quite likely. It is very probable that *Pygidium* occurs in the mountain streams all through this region. At La Serena two species of peje rey, *Basilichthys microlepidotus* and *Cauque brevianalis*, were taken with gold fish, German carp and lizas or Mugil.

At Choapa where another small stream passes, I caught the common northern peje rey and the common catfish or bagrecito, *Pygidium areolatum*. The region between Copiapo and La Calera on the Rio Aconcagua is abundantly supplied with valleys and river courses, all the apparatus to take care of a large amount of water. No doubt the region at one time not far remote took care of an abundant rainfall. At present, the water supply is inadequate for the facilities to convey it to the ocean. The fishes in this area, very limited in species, must all be looked upon as relicts, leftovers as the streams in which they occur are leftovers from a former very different condition.

In Paradise Valley, "Valparaiso," we are in the region of permanent streams which increase in size southward to the Bio Bio.

There are a few small lakes in many of the river basins from the north to the Bio Bio (Plate X.).

With the Rio Tolten in latitude 39° begins a series of large lakes which reach to Puerto Montt. In great contrast to the north, south central Chili is very well watered indeed.

THE NATURE AND DISTRIBUTION OF THE FISH-FAUNA.

The number of fishes inhabiting the rivers of Chili is disproportionately small. The fauna is distinctly Patagonian. Several species, however, are confined to Chili.

Six species of lampreys ascend the rivers of central Chili to spawn. They are reported to occur at times in vast numbers. I secured several hundred larvæ in a short time from mud and sand

in the bottom of the Rio Rahue at Osorno. *Geotria australis* occurs in Australia as well as in Chili.

Velasia chilensis is very rare, and as far as known, is limited to Chili.

Velasia stenostomus is found in New Zealand as well as in Chili.

One species of the genus *Caragola*, *C. lapicida*, and two species of *Mordacia*, *M. acutidens* and *M. Anzwandteri*, occur in the streams of Chili. They are much smaller than *Velasia* and *Geotria*. The genus *Mordacia* is also found in Australia.

Of catfishes, there are two families. The Diplomystidæ are represented by *Diplomyste Chilensis* and are confined to Chili and Patagonia. They are distinguished by the functional maxillary, a bone rudimentary in most other catfishes, but in this species bearing teeth.

The Pygidiidæ confined to South America, but within it found everywhere from the sea to Lake Titicaca, and from Panama to Patagonia, are represented by three genera.

Nematogenys, the "bagre" of the Santiago market, is confined to Chili. It reaches a considerable size. It seems to be at its best in the Maipo basin, but occurs as far south as Lautaro. It is probably nearer the original of this family than any other living species.

Pygidium arcولاتum is found everywhere south of Choapa. Its relative *P. Chiltoni* is more restricted in its distribution. The genus is found in all mountain streams from 300 feet to 12,000 south of Panama.

Hatcheria, as far as known, is confined to Chili and northern Patagonia; one species occurs between the Bio Bio and Lautaro.

Cheirodon pisciculus is a small fish belonging to a genus widely distributed between Panama and Rio Grande do Sul and the La Plata basin. It lives in weedy stretches of quiet water. It occurs from Vallenar south at least to Puerto Montt, wherever conditions are favorable. The northernmost range of the genus is much nearer the equator than Vallenar. Its known southernmost range, 41° 18', is much farther from the equator than the farthest north for any of the family of Characins to which it belongs. It has under-

gone such modifications southward and northward of the Bio Bio (where it is typical for the genus), that at least three species are recognizable.

The peje reyes, *Austromeniidae*, *Basilichthys* and *Cauque* are of great economic importance. *Austromeniidae* is confined to the ocean.

Basilichthys is found in the rivers from the Rimac south. Three species are recognizable, one in Peru, one in Chili, north of Santiago, the third from Santiago southward. *Cauque* is found in the rivers and lakes of Chili and Patagonia from La Serena south.

Perch-like fishes of the genus *Percichthys* are abundant in Chili from the Aconcagua south to Cape Horn and in Patagonia.

Percilia is a miniature of *Percichthys*. It is brilliantly colored and has both the appearance and habit of the North American darters.

Of great interest are the species of the genera *Aplochiton* and *Galaxias*, the latter found in Australia as well as in Chili.

One of the species of *Aplochiton* (*marinus*) certainly lives in the sea as well as in fresh water. In the sea it is colorless, in the rivers it becomes covered with roundish spots. Another species, *Aplochiton zebra*, lives and spawns in fresh water. It has cross-bars of varying number, width, and intensity, and is at its best in small brooks. A third species (*teniatus*), in many ways intermediate between the two, lives largely in lakes.

Of the genus *Galaxias*, two species are very abundant, while another one, *globiceps*, has been taken in but one locality. *Galaxias maculatus* is very abundant from the Bio Bio south. It is very probable that it descends to the sea to spawn. In April or thereabout great masses of its young ascend the rivers in which it occurs. *Galaxias platei* is principally at home in small brooks.

A related minute fish, *Brachygalaxias bullocki*, is confined to Chili.

A species of *Orestias* (*Agassizii*) occurs at L. Ascotan, just within the limits of Chili along the railway between Antofagasta and La Paz. The genus *Orestias* occurs most abundantly in Lake Titicaca. Since tributaries of the Desaguadero, the outlet of Lake Titicaca, flow for some distance through Chilian territory, other species of *Orestias* technically belong to the fauna of Chili. They

will be considered in a monograph on the fauna of Titicaca which is in preparation.

The genera with representatives in New Zealand or Australia are marked *. The species found in both continents are marked †.

The dry region between Copiapo and the Aconcagua is a region of leftovers. The Aconcagua and the region south to the Bio Bio may be termed Chilian. Here occurs one genus not found elsewhere, *Nematogenys*, and here occur the genera *Basilichthys*, *Percichthys*, *Percilia*, *Diplomyste* that are peculiar to southern South America. It also contains, as visitors, several lampreys.

The region from the Bio Bio to near Valdivia is distinguished by the presence, in addition to most of the species of the central Chilian region, of *Galaxias*, *Aplochiton*, not found north of the Bio Bio, of *Caragola*, *Valasia* and *Geotria*, found occasionally northward. Most of these are genera also found in and about Australia and New Zealand. The genera *Galaxias* and *Aplochiton* while present form but a small, inconspicuous portion of the fauna. The region from Valdivia south to Puerto Montt may be termed Austro-Chilian. In this region while *Percichthys* and other Chilian genera remain, the dominant genera are *Aplochiton* and the Australian *Galaxias*, *Valasia*, *Geotria* and *Caragola*.

The facts that *Caragola*, *Valasia* and *Geotria* regularly live in the sea, that some species of *Aplochiton* live and spawn in the sea, and that some species of *Galaxias* spawn in the sea and run up the streams probably account for the presence of most of these in Australia and Chili without requisitioning an antarctic continent connecting South America and Australia, warm enough to enable these fishes to migrate from one continent to the other by a fresh-water route.

SUMMARY.

There is but one genus of fresh-water fishes in Chili that recalls the tropics. It is the genus *Cheirodon* widely distributed from Panama to Buenos Aires.

²² La Calera, also including records of Valparaiso.

²³ Including Santiago Market, Peñafior, Llo Lleo, Hospital and El Flor de Maipo.

²⁴ Including Ensenada, Rio Pescado, Puerto Varas and Abtao.

²⁵ Including Casa Panque, Peulla and Salto de Petrohué.

